



Aalborg Universitet

AALBORG UNIVERSITY
DENMARK

Parametric study of antenna with parasitic element for improving the hearing aids compatibility of mobile phones and the Specific absorption rate in the head

Bonev, Ivan Bonev; Franek, Ondrej; Pedersen, Gert Frølund

Published in:

Progress In Electromagnetics Research Symposium PIERS 2011 in Marrakesh, Morocco, 20-23 March, 2011

Publication date:

2011

Document Version

Early version, also known as pre-print

[Link to publication from Aalborg University](#)

Citation for published version (APA):

Bonev, I. B., Franek, O., & Pedersen, G. F. (2011). Parametric study of antenna with parasitic element for improving the hearing aids compatibility of mobile phones and the Specific absorption rate in the head. In *Progress In Electromagnetics Research Symposium PIERS 2011 in Marrakesh, Morocco, 20-23 March, 2011* (pp. 1885-1889). The Electromagnetics Academy. Progress in Electromagnetics Research Symposium <http://piers.org/piersproceedings/piers2011MarrakeshProc.php?searchname=Ivan+Bonev>

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal -

Take down policy

If you believe that this document breaches copyright please contact us at vbn@aub.aau.dk providing details, and we will remove access to the work immediately and investigate your claim.

Parametric Study of Antenna with Parasitic Element for Improving the Hearing Aids Compatibility of Mobile Phones and the Specific Absorption Rate in the Head

I. B. Bonev, O. Franek, and G. F. Pedersen

Antennas, Propagation and Radio Networking Section
Department of Electronic Systems, Faculty of Engineering and Science
Aalborg University, Denmark

Abstract— In this paper, we present a design of a planar inverted F antenna (PIFA) mounted on a ground plane with form factor corresponding to a typical candy bar type of mobile phone. A quarter-wavelength parasitic element is introduced with the objective to both decrease the specific absorption rate (SAR) and improve the level of hearing aid compatibility (HAC). By varying the position of the parasitic element we have achieved reduction in the averaged SAR in the order of 20% in the 1900 MHz GSM band. However, the improvement of HAC due to electric and magnetic fields has been found only marginal.

1. INTRODUCTION

Near fields of mobile phone antennas have been an interesting topic among the academia and the industry as their understanding and correct evaluation are of great importance when studying the hearing aids compatibility (HAC) and the specific absorption rate (SAR) in the head, both being crucial parameters of mobile phones for their market approval. Several studies have shown that the electromagnetic interference in hearing aids due to GSM mobile phones has an annoying effect on the user and a negative influence on the intelligibility of the speech [1–5]. The current HAC standard [6] suggests categorizing mobile phones by the near fields they produce in free space. In [7], the authors have shown a significant difference between the near fields and the HAC under more realistic condition when the head is present, as opposed to the free space case. Moreover, in the case of HAC evaluation, the great variety of the hearing aids available on the market complicates additionally the HAC estimation of the mobile phones.

Several techniques for manipulating the near fields and reducing the absorption loss in the head have been investigated [9–11]. In this contribution, we make use of a parasitic element next to a planar inverted F antenna (PIFA) with the objective to reduce both HAC and SAR. Numerical parametric study of position of the parasitic element is performed using the finite-difference time-domain method (FDTD) [12] and resulting SAR, electric and magnetic fields are plotted.

2. ANTENNA CONFIGURATION

The investigated PIFA antenna with a ground plane and the parasitic element is described in Figs. 1(a), (b). The total volume of the antenna is $40 \times 100 \times 10$ mm which is a typical dimension of a candy bar mobile phone. The antenna has been designed to cover both the 850 MHz (low band) and 1900 MHz (high band) GSM bands. The parasitic element has two sections — vertical and horizontal. The vertical segment is perpendicular to the ground plane with length of 10 mm and the horizontal segment is located along the width of the ground plane and its length is 35 mm, chosen to be approximately equal to quarter of the wavelength at the high GSM band. The dimensions x and y define the position of the vertical segment on the ground plane. Consequently, for $x = 0$ mm and $x = 5$ mm, the parasitic element is directed to the left (as depicted in Figs. 1(a), (b) whereas for $x = 35$ mm and $x = 40$ mm element is directed to the right.

According to standard [8], SAR is evaluated using the specific anthropometric mannequin head as the mobile phone is placed in predefined right cheek position. However, good approximation can be achieved using a generic cubical head model [7], and this has been used for SAR evaluation also in the present study (Fig. 1(c)).

3. HAC OF MOBILE PHONES

The exact procedure of HAC evaluation is described in the last version of the ANSI standard [6]. It is assumed that concurrent operation of a mobile phone and a hearing aid is acceptable only if the HAC category is at least 5. The HAC category is defined as a sum of the category of the mobile

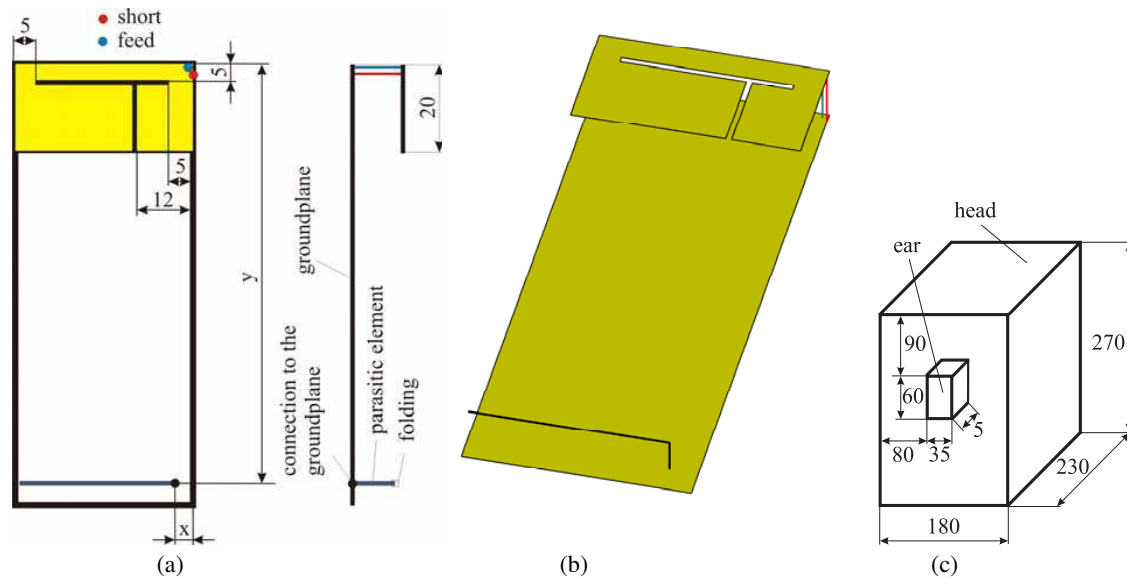


Figure 1: Layout of the initial dual-band PIFA and with the parasitic element (a), 3-D view of the same (b) and generic cubical model for the SAR computations.

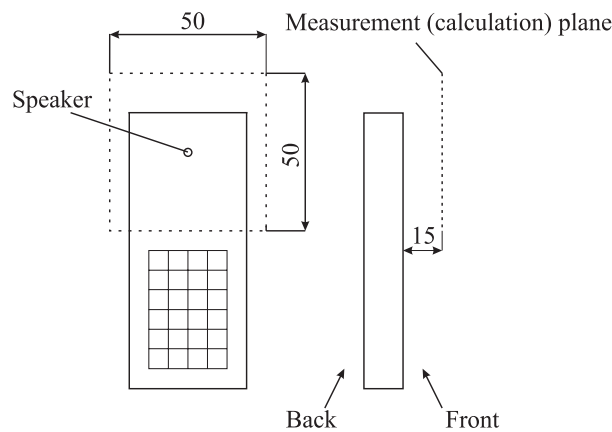


Figure 2: Setup for the NF measurement according to the current HAC standard [6].

phone (dependent on the measured near fields) and the category of the hearing aid (dependent on the hearing aid immunity). Because the hearing aids currently available on the market can achieve hearing aid category equal to 2 easily, the aim for the mobile phone manufacturers is to ensure that the mobile phone has category 3 or higher. Our focus will be on the evaluation of the near fields generated by the mobile phone. The standard specifies measurement of electric and magnetic fields in a plane 50×50 mm at a fixed distance 15 mm from the mobile phone (Fig. 2).

The phone speaker and the center of the measurement plane lie on a line perpendicular to the phone. After the data are obtained for both electric and magnetic fields, the measurement plane is divided into nine equal subgrids. For each electric and magnetic subgrid, the maximum value is estimated. An exclusion procedure is applied with following rules:

- The center sub-grid can not be excluded;
- Three electric and three magnetic subgrids have to be eliminated as at least 4 out of the 6 left sub-grids have to be common for both E and H field;
- For each electric and magnetic field the excluded subgrids have to be contiguous;

Then, the mobile phone category is defined by the maximum electric and magnetic values after the exclusion, see Table 1.

4. NUMERICAL RESULTS

The averaged SAR values in the low and high GSM bands dependent on the x and y positions of the parasitic element are presented in Fig. 3. Two families of curves are shown — The higher one

for SAR averaged over 1 g and the lower one for SAR averaged over 10 g. In the 850 MHz band, the parasitic element has an influence only when positioned at the very bottom of the ground plane, reducing the SAR by 10%. On the other hand, the effective range is wider in the 1900 MHz where the optimum occurs around $y = 80$ mm and the SAR is reduced by 20%.

However, as can be seen in Fig. 4, the parasitic element has only marginal effect on the peak and averaged values of electric and magnetic fields relevant to the HAC. In addition, the field levels

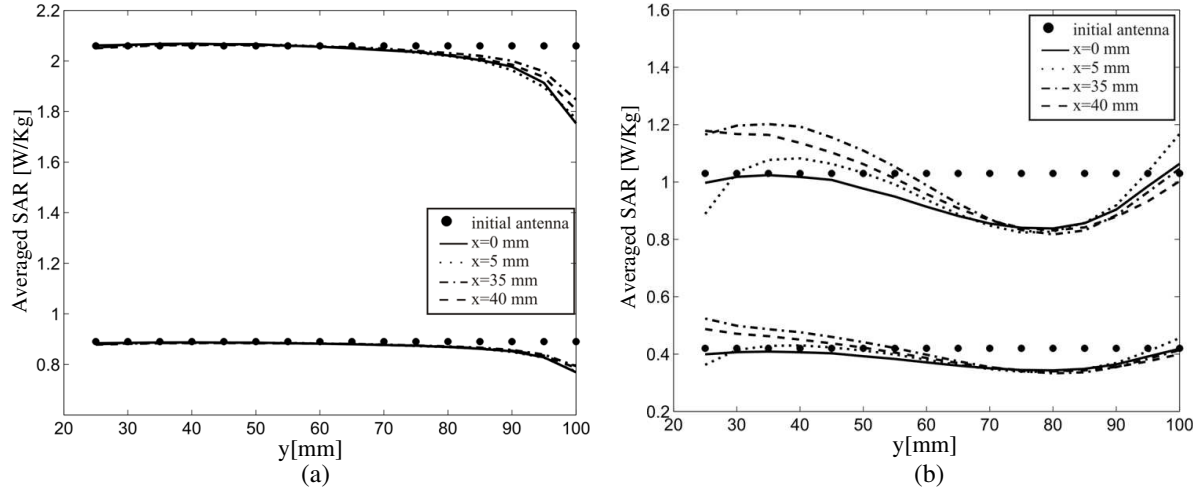


Figure 3: 1g-(upper lines) 10 g-(lower lines) averaged SAR in the 850 (a) and 1900 (b) GSM bands.

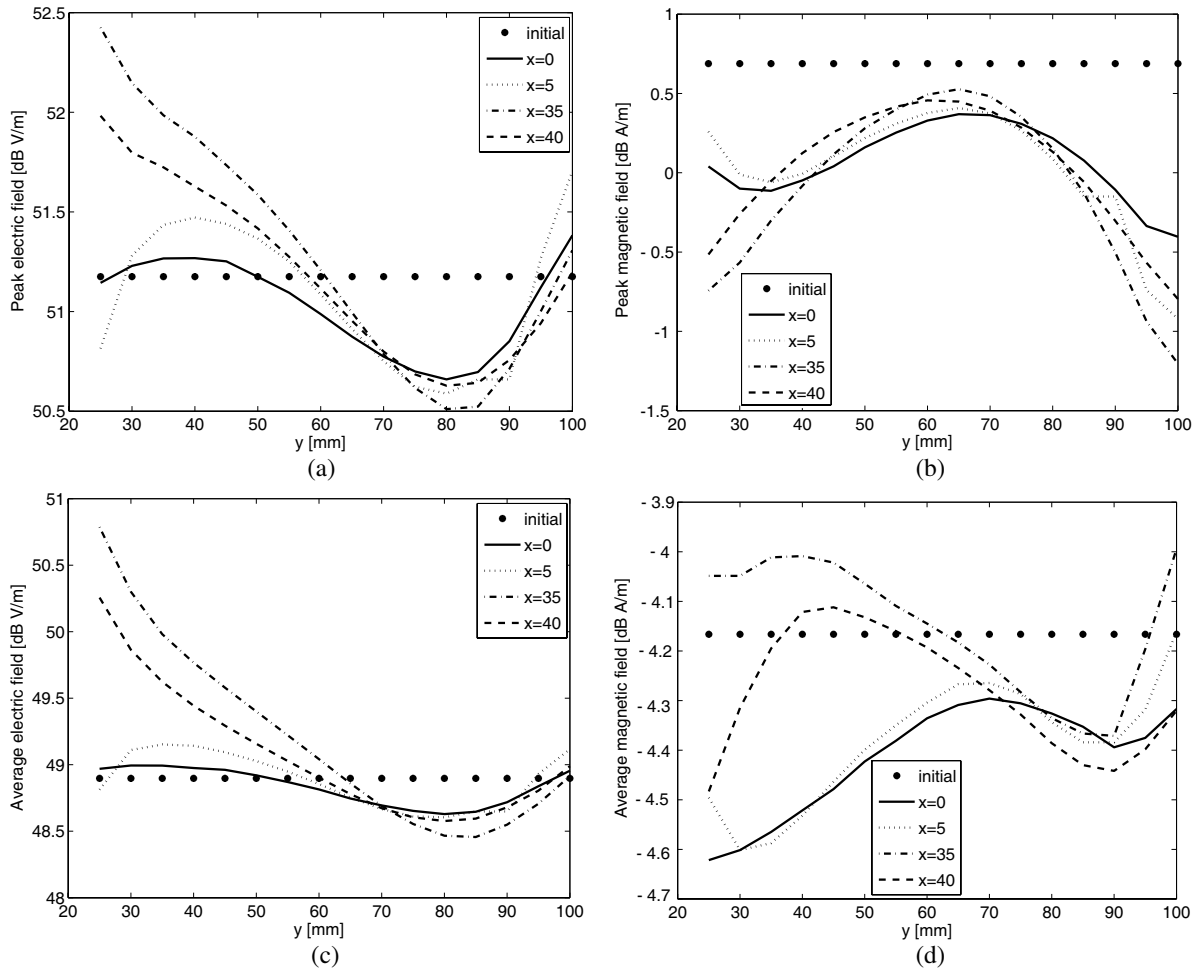


Figure 4: Peak electric (a), peak magnetic (b), average electric (c) and average magnetic (d) fields at the 15 mm distance from the antenna in 1900 MHz GSM band.

Table 1: Phone emission limits and categories (for frequencies below 960 MHz the values are 10 dB higher).

| Category | Telephone RF parameters (above 960 MHz) | |
|----------|---|-------------------|
| | E field [dBV/m] | H field [dBA/m] |
| M1 | 48.5 to 53.5 | −1.9 to 3.1 |
| M2 | 43.5 to 48.5 | −6.9 to −1.9 |
| M3 | 38.5 to 43.5 | −11.9 to −6.9 |
| M4 | < 38.5 | < −11.9 |

are not even close to the boundaries between the standardized HAC categories (see Table 1), so the benefit is nonexistent in this aspect.

One more configuration has been tried, with the PIFA antenna on the bottom of the ground plane and the parasitic element on the top (mirror image of the original antenna), but the results were qualitatively the same.

5. CONCLUSIONS

Parametric study of a PIFA antenna with parasitic radiator with the objective of reduction of improving both HAC and SAR has been performed. It has been demonstrated that the proposed parasitic element, when properly positioned, can decrease the SAR in the 1900 MHz GSM band by 20%. However, attempts to achieve any significant improvement of HAC have been largely unsuccessful. One of the possible reasons might be the procedure of determining the HAC itself, which might “average out” any possible improvements. The fact that only the fields at the distance of exactly 15 mm are relevant to HAC might also play a role, as opposed to the standardized SAR procedure which performs the average volumetrically.

ACKNOWLEDGMENT

The authors would like to thank Mr Morten Christensen and Mr. Sinan Koksoy for their valuable discussions.

REFERENCES

1. Strange, D., D. Byrne, K. Joyner, and G. Symons, “Interference to hearing aids by the digital mobile telephone system, global systems for mobile communications,” NAL Report, May 1995.
2. “Hearing aids and GSM mobile telephones: interference problems, methods of measurements and levels of immunity,” EHIMA GSM Project Final Report, 1995.
3. Ravindram, A., R. Schlegel, H. Grant, P. Mathews, and P. Scates, “Study measures interference to hearing aids from digital phones,” *The Hearing Journal*, Vol. 50, 32–34, April 1997.
4. Scopec, M., “Hearing aid electromagnetic interference from digital cellular telephones,” *18-th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 1996.
5. Scopec, M., “Hearing aid electromagnetic interference from digital cellular telephones,” *IEEE Transactions on Rehabilitation Engineering*, Vol. 6, No. 2, 1998.
6. “American national standard methods of measurement of compatibility between wireless communication devices and hearing aids,” ANSI C63.19, 2007.
7. Bonev, I. B., M. Christensen, O. Franek, and G. F. Pedersen, “Impact of the on the hearing aids compatibility,” *Applied Computational Electromagnetics Society Journal*, November 2010.
8. Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body due to Wireless Communications Devices: Experimental techniques, IEEE Standard 1528, 2003
9. Bario, S. C. D. and I. B. Bonev, “On the effectiveness of a Z element for enhancement of matching, gain and reactive near fields of a small antenna,” *Fourth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics (METAMATERIALS)*, Karlsruhe, Germany, 2010.
10. Bonev, I. B., “Reduction of the absorption loss in the head by loading a pifa with metamaterial and high permittivity structures,” *Fourth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics (METAMATERIALS)*, Karlsruhe, Germany, 2010.

11. Bario, S. C. D., I. B. Bonev, M. Pelosi, O. Franek, and G. F. Pedersen, “Reduction of the absorption loss in the head via a metamaterial inspired Z antenna,” *5th European Conference on Antennas and Propagation*, Rome, Italy, 2011.
12. Wang, Y., I. B. Bonev, J. Nielsen, I. Kovacs, and G. F. Pedersen, “Characterization of the indoor multi-antenna body-to-body radio channel,” *IEEE Trans. on Antennas and Propag.*, Vol. 56, No. 12, April 2009.